THE "CHALLENGER" IN THE ATLANTIC[1]

II.

IT still seems but the other day when every zoologist believed with Edward Forbes that not very far below the surface of the sea there existed a region where life was unknown, or where at the most, if it existed it showed but a few sparks, which only served "to mark its lingering presence;" and yet even when Forbes was writing thus, Sir John Ross had brought up from some 800 fathoms deep in Baffin's Bay, "a beautiful *Caput medusæ*," and the present president[2] of the Royal Society had written (August 31, 1845), "It is probable that animal life exists at a very great depth—in the ocean." "On one occasion, off Victoria Land, between the parallels of 71° and 78° S.L., the dredge was repeatedly employed, once with great success at 380 fathoms," and "on another occasion the sounding-line brought up distinct traces of animal life from a depth of 550 fathoms." The history, however, of the subject, is to be found recorded in Sir Wyville Thomson's "Depths of the Sea," and we only here refer to it to remind the reader how completely changed are the general ideas on this subject; and we learn without surprise that "the most prominent and remarkable biological result of the *Challenger's* voyage is the final establishment of the fact that the distribution of living [animal] beings has *no depth limit*, but that animals of all the marine invertebrate classes, and probably fishes also, exist over the whole of the flora of the ocean;" but although life is thus universally extended, probably the number of species as well as of individuals diminishes after a certain depth is reached. This distribution of animal life depends in a marked degree either upon the nature of the sea-bottom or upon the conditions which modify the nature of that bottom. The fauna at great depths was found to be remarkably uniform, and the distribution area seemed to depend mainly on the maintenance of a tolerably uniform temperature. It is curious to note that the families which are peculiarly characteristic of the abyssal fauna, contain a larger number of species and individuals, and these are larger and more fully developed in the Antarctic Ocean, than they are in the Atlantic and the North Pacific.

Though the task of determining the various animal forms procured will occupy a number of specialists for several years, still we have several glimpses of the riches of the ocean fauna in these two volumes. Among these the pretty Hexactinellid sponges, the stalked crinoids, and the echinoids seem to hold foremost places. The stalked crinoids with their lily-like forms are the most remarkable of these, not only on account of their extreme rarity, but also on account of the special interest of their relation to many well-known fossil forms. Of one of these fine forms we give the accompanying illustration (Fig. 3). It was dredged from a depth of about 400 fathoms, near the Island of San Miguel. It belongs to the genus *Pentacrinus*, and has been called after Capt. Maclear, R.N., the commander of the *Challenger*. The lily-shaped head is about 3½ inches in height, and the stalk may have been several inches longer. The scientific description of such a form must necessarily be very technical, and not easily to be understood by the general reader, who, however, cannot fail to get a correct idea of its general form and

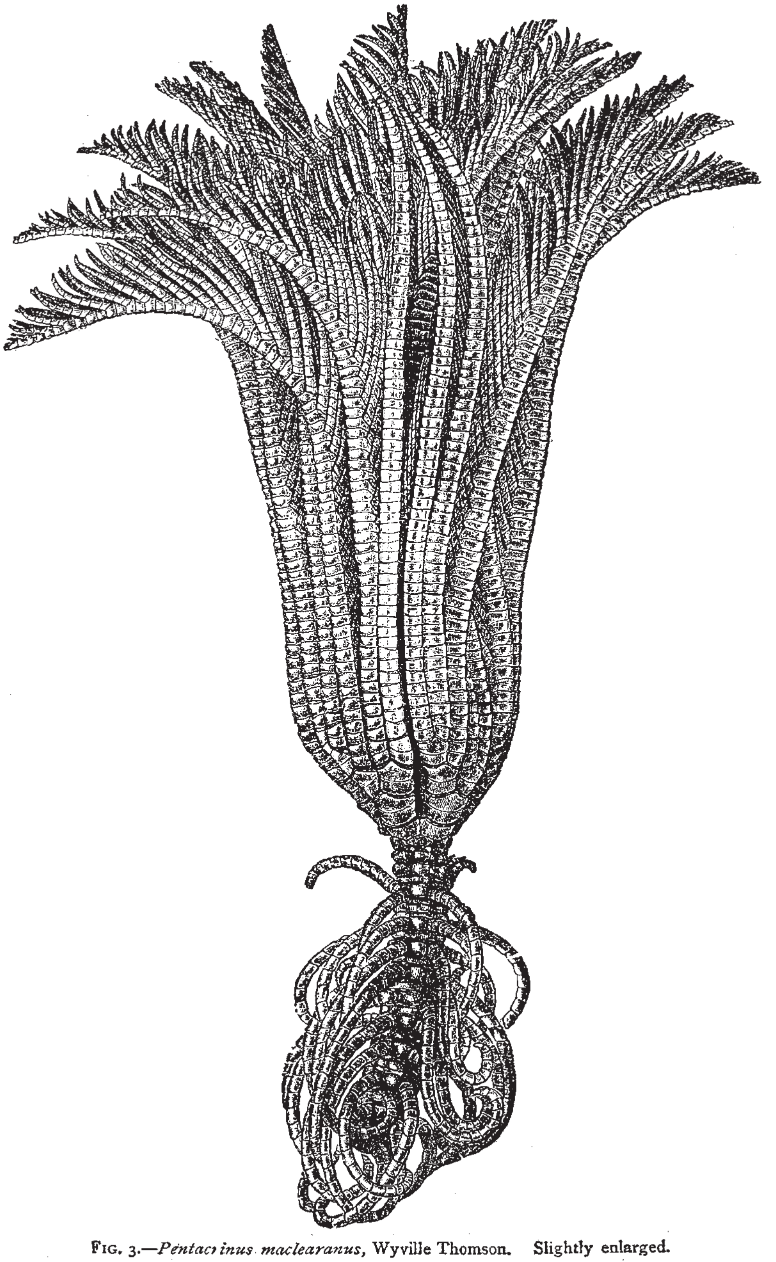

FIG. 3.—*Pentacrinus maclearanus*, Wyville Thomson. Slightly enlarged.

[1] "The Voyage of the *Challenger*. The Atlantic: a Preliminary Account of the General Results of the Exploring Voyage of H.M.S. *Challenger* during the Year 1873 and the Early Part of the Year 1876." By Sir C. Wyville Thomson, Knt., LL.D., F.R.SS. L. and E., &c., Regius Professor of Natural History in the University of Edinburgh, and Director of the Civilian Scientific Staff of the *Challenger* Exploring Expedition. Two volumes. Published by Authority of the Lords Commissioners of the Admiralty. (London: Macmillan and Co., 1877.) Continued from p. 148.

[2] Sir Joseph Hooker, C.B.

appearance from the illustration. The special volume in which the whole group of these lily-like starfish will be described is, we understand, to be from the pen of Sir Wyville Thomson.

Though the zoological treasures obtained by dredging were often very great, yet sometimes this often prolonged operation ended in utter disappointment; for example:—The vessel was on her way from Bahia to the Cape, when, on October 2, "we saw our first albatross sailing round the ship with that majestic careless flight which has been our admiration and wonder ever since; rising and sinking, and soaring over us in all weathers, utterly regardless of the

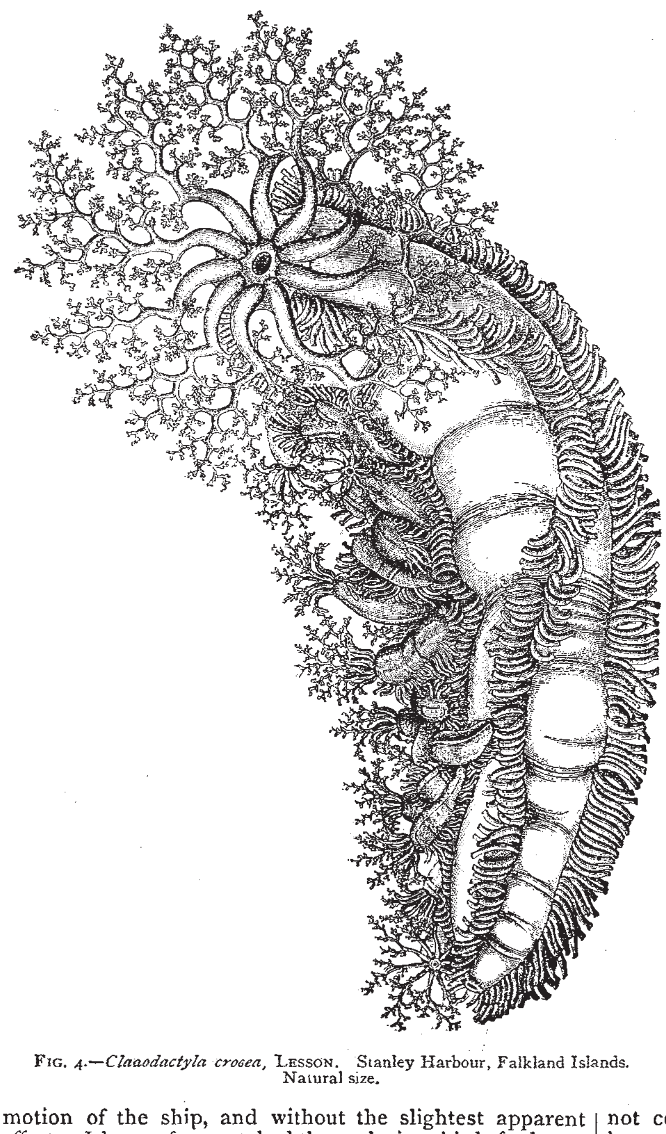

FIG. 4.—*Claaodactyla crocea*, LESSON. Stanley Harbour, Falkland Islands. Natural size.

motion of the ship, and without the slightest apparent effort. I have often watched these glorious birds for hours from the bridge, and notwithstanding all we know or think we know about the mechanics of flight, to the last I felt inclined to protest that for so heavy a bird to support itself motionless in the air, and perform its vigorous evolutions without a perceptible movement of the wings, was simply impossible by any mechanical means of which we have the least conception.

"On the 3rd we sounded in 2,350 fathoms with a bottom of red mud, still due apparently in a great degree to the South American rivers, and a bottom temperature of $0^{\circ}\cdot 8$ C. The trawl was lowered, and on heaving in, it came up apparently with a heavy weight, the accumulators being stretched to the utmost. It was a long and weary wind-in, on account of the continued strain; at length it came close to the surface, and we could see the distended net through the water; when, just as it was leaving the water, and so greatly increasing its weight, the swivel between the dredge-rope and the chain gave way, and the trawl with its unknown burden quietly sank out of sight. It was a cruel disappointment—every one was on the bridge, and curiosity was wound up to the highest pitch; some vowed that they saw resting on the beam of the vanishing trawl the white hand of the mermaiden for whom we had watched so long in vain; but I think it is more likely that the trawl had got bagged with the large sea-slugs which occur in some of these deep dredgings in large quantity, and have more than once burst the trawl net."

Among the interesting creatures met with living, not in the depths of the sea, but in this instance living amid the fronds of one of the larger algæ, was a Holothuroid, of which we have the following account:—

"The weather while we were at the Falklands was generally cold and boisterous, and boat-work was consequently uncomfortable and frequently impracticable, except in the shallow water within the harbour; we had, however, two or three days' dredging in the pinnace, and made a pretty fair account of the submarine inhabitants of our immediate neighbourhood. *Macrocystis pyrifera*, the huge tangle of the Southern Seas, is very abundant in Stanley Harbour, anchored in about ten fathoms, the long fronds stretching for many yards along the surface and swaying to and fro with the tide. Adhering to the fronds of macrocystis there were great numbers of an elegant little cucumber-shaped sea-slug (*Cladodactyla crocea*, Lesson, sp.), from 80 to 100 mm. in length by 30 mm. in width at the widest part, and of a bright saffron-yellow colour. The mouth and excretory opening are terminal; ten long, delicate, branched oral tentacles, more resembling in form and attitude those of *Ocnus* than those of the typical *Cucumariæ*, surround the mouth; the perisom is thin and semi-transparent, and the muscular bands, the radial vessels, and even the internal viscera can be plainly seen through it. The three anterior ambulacral vessels are approximated, and on these the tentacular feet are numerous and well developed, with a sucking-disc supported by a round cribriform calcareous plate, or more frequently by several wedge-shaped radiating plates arranged in the form of a rosette; and these three ambulacra form together, at all events in the female, a special ambulatory surface.

"The two ambulacral vessels of the 'bivium' are also approximated along the back, and thus the two interambulacral spaces on the sides of the animal, between the external trivial ambulacra and the ambulacra of the bivium, are considerably wider than the other three; consequently, in a transverse section, the ambulacral vessels do not correspond with the angles of a regular pentagon, but with those of an irregular figure in which three angles are approximated beneath and two above. In the female the tentacular feet of the dorsal (bivial) ambulacra are very short; they are provided with sucking-discs, but the calcareous support of the suckers is very rudimentary, and the tubular processes are not apparently fitted for locomotion. In the males there is not so great a difference in character between the ambulacra of the trivium and those of the bivium; but the tentacles of the latter seem to be less fully developed in both sexes, and I have never happened to see an individual of either sex progressing upon, or adhering by, the water-feet of the dorsal canals.

"In a very large proportion of the females which I examined, young were closely packed in two continuous fringes adhering to the water-feet of the dorsal ambulacra. The young were in all the later stages of growth, and of all sizes from 5 up to 40 mm. in length; but all the young attached to one female appeared to be nearly of the same age and size. Some of the mothers with older families had a most grotesque appearance—their bodies entirely hidden by the couple of rows, of a dozen or so each, of yellow vesicles, like ripe yellow plums ranged along their backs, each surmounted by its expanded crown of oral tentacles; in the figure the young are represented about half-grown. All the young I examined were miniatures of their parents; the only marked difference was that in the young the ambulacra of the bivium were quite rudimentary—they were externally represented only by bands of a somewhat darker orange than the rest of the surface, and by lines of low papillæ in the young of larger growth; the radial vessels could be well seen through the transparent body-wall; the young attached themselves by the tentacular feet of the trivial ambulacra, which are early and fully developed.

"We were too late at the Falklands (January 23) to see the process of the attachment of the young in their nursery, even if we could have arranged to keep specimens alive under observation. There can be little doubt that, according to the analogy of the class, the eggs are impregnated either in the ovarial tube or immediately after their extrusion, that the first developmental stages are run through rapidly, and that the young are passed back from the ovarial opening, which is at the side of the mouth, along the dorsal ambulacra, and arranged in their places by the automatic action of the ambulacral tentacles themselves."

One other illustration we take, this time from an animal living in the surface water, though it sinks, when dead, to the bottom of the sea (Fig. 5).

"*Hastigerina murrayi* is very widely distributed on the surface of warm seas, more abundant, however, and of larger size in the Pacific than in the Atlantic. The shell consists of a series of eight or nine rapidly enlarging inflated chambers coiled symmetrically on a plane; the shell-wall is extremely thin, perfectly hyaline, and rather closely perforated with large and obvious pores. It is beset with a comparatively small number of very large and long spines. The proximal portion of each spine is formed of three laminæ, delicately serrated along their outer edges, and their inner edges united together. The spines, when they come near the point of junction with the shell, are contracted to a narrow cylindrical neck, which is attached to the shell by a slightly expanded conical base. The distal portion of the spine loses its three diverging laminæ, and becomes flexible and thread-like. The sarcode is of a rich orange colour from included highly-cooured oil-globules.

"On one occasion in the lPacific, when Mr. Murray was out in a boat in a dead calm collecting surface creatures, he took gently up in a spoon a little globular gelatinous mass with a red centre, and transferred it to a tube. This globule gave us our first and last chance of seeing what a pelagic foraminifer really is when in its full beauty. When placed under the microscope it proved to be a *Hastigerina* in a condition wholly different from anything which we had yet seen. The spines, which were mostly unbroken, owing to its mode of capture, were enormously long, about fifteen times the diameter of the shell in length; the sarcode, loaded with its yellow oil-cells, was almost all outside the shell, and beyond the fringe of yellow sarcode the space between the spines, to a distance of about twice the diameter of the shell all round, was completely filled up with delicate *bullæ*, like those which we see in some of the Radiolarians, as if the most perfectly transparent portion of the sarcode had been blown out into a delicate froth of bubbles of uniform size. Along the spines fine double threads of transparent sarcode, loaded with minute granules, coursed up one side and down the other, while between the spines independent thread-like pseudopodia ran out, some of them perfectly free, and others anastomosing with one another or joining the sarcodic sheaths of the spines, but all showing the characteristic flowing movement of living protoplasm."

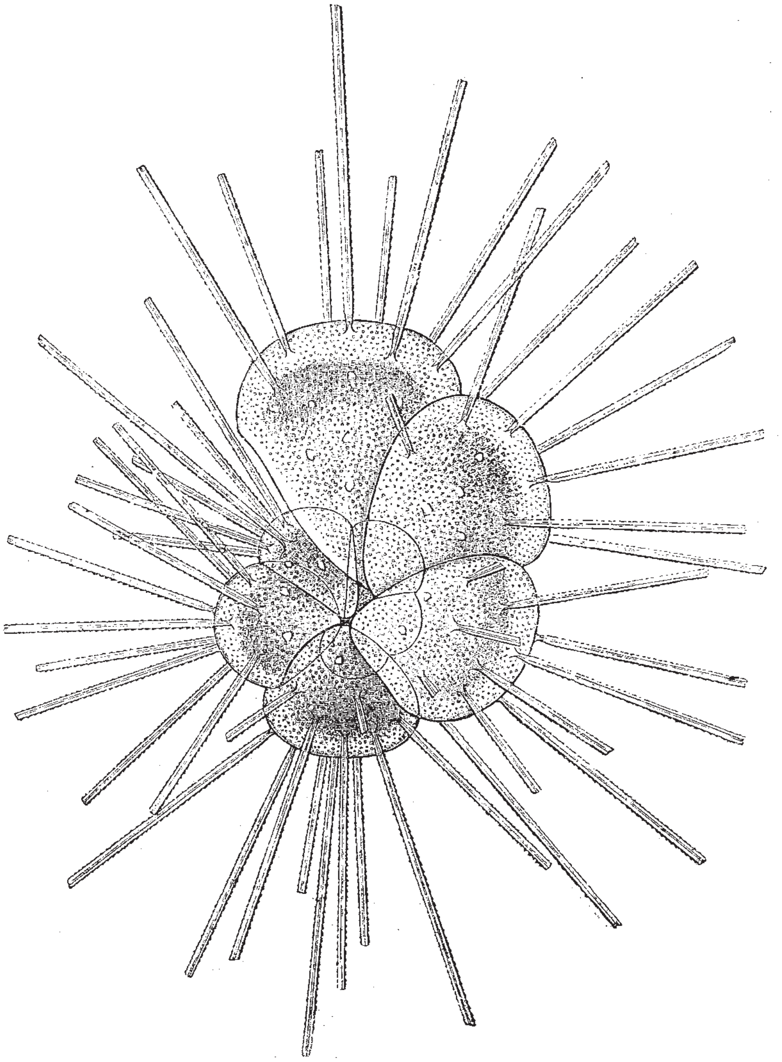

Fig. 5.—*Hastigerina murrayi*, Wyville Thomson. From the surface. Fifty times the natural size.

It would be easy to extend our notice on the animal forms alluded to, but our space forbids. It is curious that no vegetable life seems to have been met with in depths below 100 fathoms. "No plants live, so far as we know, at great depths in the sea; and it is in all probability essentially inconsistent with their nature and mode of nutrition that they should do so." But parasitic alga have been detected in some of the deep-sea corals, and we are a little surprised to see the position of the diatoms queried; surely their plant affinities cannot now be discussed, and without these little plants we fancy some of the plant-eating deep-sea forms of animal life would be badly off. Holothuroids are especially fond of them.

The following general conclusions are arrived at:—

"1. Animal life is present on the bottom of the ocean at all depths.

"2. Animal life is not nearly so abundant at extreme as it is at more moderate depths; but, as well-developed members of all the marine invertebrate classes occur at all depths, this appears to depend more upon certain causes affecting the composition of the bottom deposits, and of the bottom water involving the supply of oxygen, and of carbonate of lime, phosphate of lime, and other materials necessary for their development, than upon any of the conditions immediately connected with depth.

"3. There is every reason to believe that the fauna of deep water is confined p incipally to two belts, one at and near the surface, and the other on and near the bottom; leaving an intermediate zone in which the larger animal forms, vertebrate and invet brate, are nearly o entirely absent.

"4. Although all the principal marine invertebrate groups are represented in the abyssal fauna, the relative proportion in which they occur is peculiar. Thus Mollusca in all their classes, Brachyourous Crustacea, and Annelida, are on the whole scarce; while Echinodermata and Porifera greatly preponderate.

"5. Depths beyond 500 fathoms are inhabited throughout the world by a fauna which presents generally the same features throughout; deep-sea genera have usually a cosmopolitan extension, while species are either universally distributed, or, if they differ in remote localities, they are markedly representative, that is to say, they bear to one another a close genetic relation.

"6. The abyssal fauna is certainly more nearly related than the fauna of shallower water to the faunæ of the tertiary and secondary periods, although this relation is not so close as we were at first inclined to expect, and only a comparatively small number of types supposed to have become extinct have yet been discovered.

"7. The most characteristic abyssal forms, and those which are most nearly related to extinct types, seem to occur in greatest abundance and of largest size in the southern ocean; and the general character of the faunæ of the Atlantic and of the Pacific gives the impression that the migration of species has taken place in a northerly direction, that is to say, in a direction corresponding with the movement of the cold under-current.

"8. The general character of the abyssal fauna resembles most that of the shallower water of high northern and southern latitudes, no doubt because the conditions of temperature, on which the distribution of animals mainly depends, are nearly similar."

These volumes form a distinct contribution to Science, and will certainly be welcomed by the scientific worker; and their interest to the general reader, who can pass over the few technical descriptions of the new forms, will be scarcely at all less.

THE MODERN TELESCOPE[1]

III.

WE know that both with object-glasses and reflectors a certain amount of light is lost by imperfect reflection in the one case, and by reflection from the surfaces and absorption in the other; and in reflectors we have generally two reflections instead of one. This loss is to the distinct disadvantage of the reflector, and it has been stated by authorities on the subject, that, light for light, if we use a reflector, we must make the aperture twice as large as that of a refractor in order to make up for the loss of light due to reflection. But Dr. Robinson thinks that this is an extreme estimate; and with reference to the four-foot reflector now in operation at Melbourne, and of which mention has already been made, he considers that a refractor of 33·73 inches aperture would be probably something like its equivalent if the glass were perfectly transparent, which is not the case.

On the assumption, therefore, that no light is lost in transmission through the object-glass, Dr. Robinson estimates that the apertures of a refractor and a reflector of the Newtonian construction must bear the relation to each other of 1 to 1·42. In small refractors the light absorbed by the glass is small, and therefore this ratio holds approximately good, but we see from the example just quoted how more nearly equal the ratio becomes on an increase of aperture, until at a certain limit the refractor, aperture for aperture, is surpassed by its rival, supposing Dr. Robinson's estimate to be correct. But with specula of silvered glass the reflective power is much higher than that of speculum metal; the silvered glass being estimated to reflect about 90 per cent.[1] of the incident light, while speculum metal is estimated to reflect about 63 per cent.; but be these figures correct or not, the silvered surface has undoubtedly the greater reflective power; and, according to Sir J. Herschel, a reflector of the Newtonian construction utilises about seven-eighths of the light that a refractor would do.

In treating of the question of the future of the telescope, we are liable to encroach on the domain of opinion, and go beyond the facts vouched for by evidence, but there are certain guiding principles which are well worthy of consideration. These have lately been discussed by Mr. Howard Grubb in a paper "On Great Telescopes of the Future." We shall take up his points *seriatim*, premising that in the two classes of telescopes, refractors and reflectors, each possesses some advantages over the other.

We may conveniently consider first the advantages which the refractor has over the reflector.

First, there is less loss of light with the former than with the latter, *as a rule*, hence for equal "space-penetrating power" the aperture of the reflector must be greater. This condition gives us a greater column of air and consequently greater atmospheric disturbance.

"The refractor having a tube closed at both ends, and the reflector being open at the upper end, the condition of air-currents is quite different in the two cases, to the disadvantage of the reflector, for in it the upper end being open, there is nothing to prevent currents of hot and cold air up and down the tube, and in and out of the aperture, and for this reason great advantage has been

[1] Continued from p. 127.

[1] Sir John Herschel, in his work on the telescope, gives the following table of reflective powers:—

After transmission through one surface of glass not in contact with any other surface	0·957
After transmission through one common surface of two glasses cemented together	1·000
After reflection on polished speculum metal at a perpendicular incidence	0·632
After reflection on polished speculum metal at 45° obliquity...	0·690
After reflection on pure polished silver at a perpendicular incidence	0·905
After reflection on pure polished silver at 45° obliquity ...	0·910
After reflection on glass (external) at a perpendicular incidence	0·043

The effective light in reflectors (irrespective of the eye-pieces) is as follows:—

Herschelian (Lord Rosse's speculum metal)	A.	0·632
Newtonian (both mirrors ditto)	B.	0·436
Do (small mirror or glass prism)...	C.	0·632
Gregorian or Cassegrain	D.	0·399
The same telescopes, all the metallic reflections being from pure silver	A.	0·905
	B.	0·824
	C.	0·905
	D.	0·819